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A u.h.f. aerial for elliptical polarisation

No. 1972/17

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION

RESEARCH DEPARTMENT

A U.H.F. AERIAL FOR ELLIPTICAL POLARISATION

Research Department Report No. **1972/17**
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A U.H.F. AERIAL FOR ELLIPTICAL POLARISATION

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(RA-100)

May 1972

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A U.H.F. AERIAL FOR ELLIPTICAL POLARISATION

Summary

A special aerial was made for tests of a proposal to reduce tidal fading to be carried out from the Rosneath site. It consists of a vertically-polarised printed panel aerial modified by the addition of a single horizontal dipole, fed with current of appropriate amplitude and phase.

1. Introduction

Viewers receiving their service across tidal waters find that the signal varies with the flow of the tide, as the path difference between the direct and water-reflected components of signal changes.[1] In many instances the signal exhibits a deep slow fade as the two components pass through the antiphase condition.

A proposal[2] (made by P.A. Laven) for overcoming this effect requires the transmission of an elliptically-polarised signal with characteristics chosen so that the reflection from the surface of a smooth sea is plane polarised at an angle of 45°; the domestic receiving aerial is then set at an angle of 45° in the other sense to reject this reflection. The efficacy of the proposal under disturbed water conditions cannot be predicted and tests are planned to establish this.

2. Specification of the polarisation

The required relative amplitudes of the vertically-polarised and horizontally-polarised components of the field (denoted E_V and E_H respectively) depend on the angle of incidence. In the Rosneath area the ideal E_H/E_V ratio varies from $0{\cdot}344\angle{-143^\circ}$ to $0{\cdot}491\angle{-158^\circ}$ depending on the direction of azimuth. In any given direction, to maintain the effective reflection coefficient at the surface of the sea below 0·1, the amplitude tolerance should be ±1 dB and the phase tolerance ±7°.

For the test aerial, a nominal E_H/E_V ratio of $0{\cdot}40\angle{-152^\circ}$ was adopted but it was thought desirable to be able to vary this, particularly in respect of the relative amplitude.

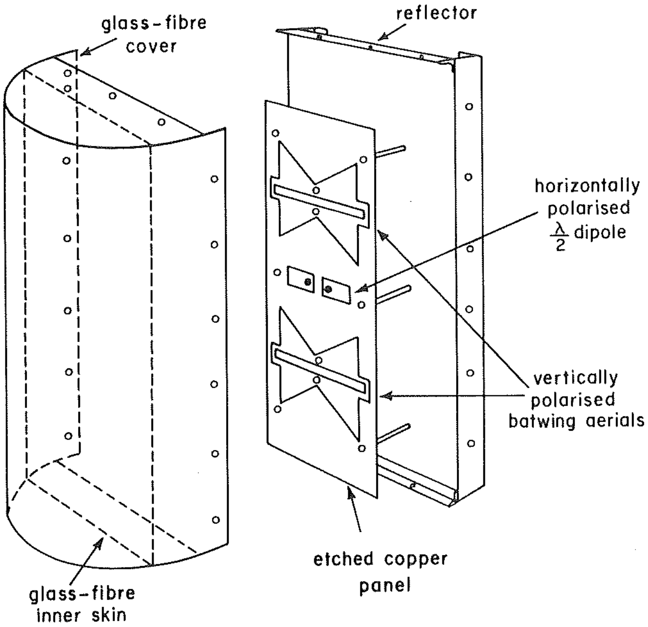
glass-fibre cover
reflector
horizontally polarised $\frac{\lambda}{2}$ dipole
vertically polarised batwing aerials
etched copper panel
glass-fibre inner skin

Fig. 1 - Modified twin-element batwing aerial panel and cover.

3. The Aerial

A prototype of the printed panel aerial[3] was used for the vertically-polarised component. To this was added a horizontal dipole printed on the same card between the batwing elements and fed through a Pawsey stub. The arrangement is shown in Fig. 1.

Initially, the relative amplitude of current in the aerials was controlled by an adjustable hybrid network[4]

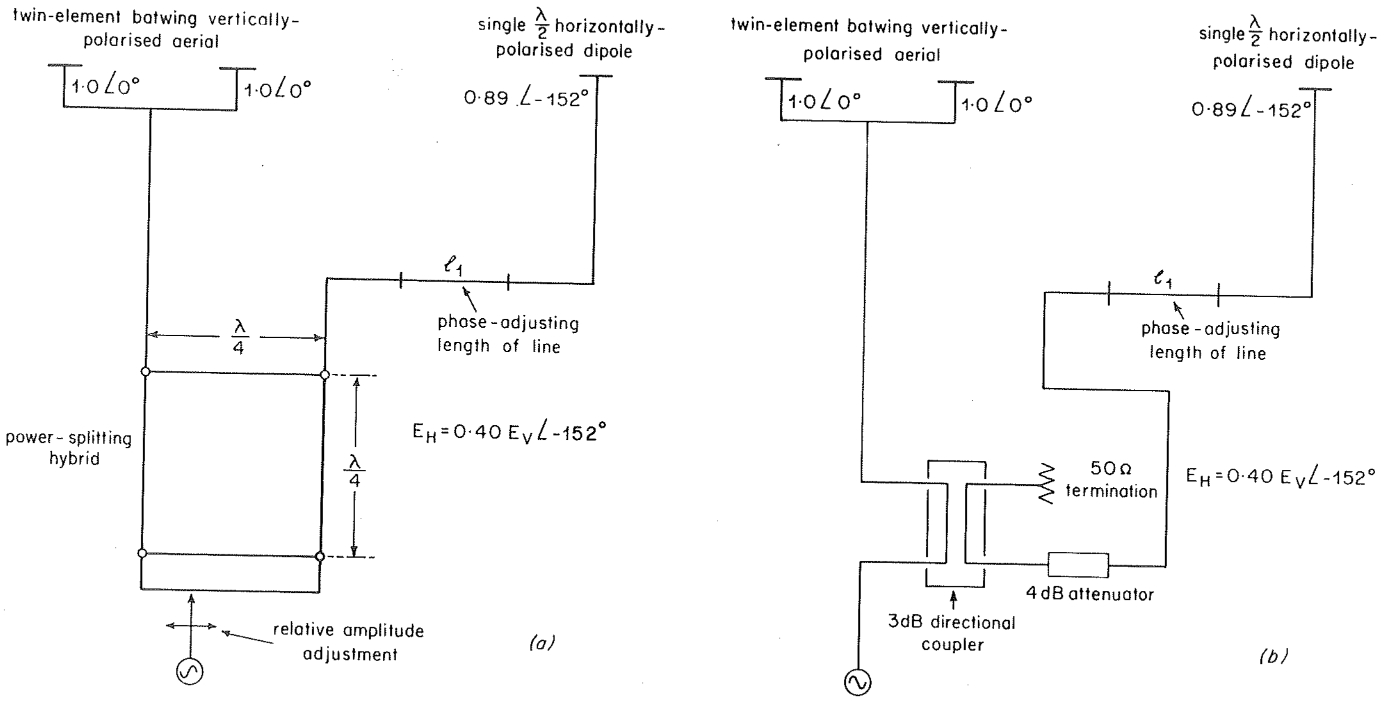
twin-element batwing vertically-polarised aerial
1·0∠0°
1·0∠0°
single λ/2 horizontally-polarised dipole
0·89 ∠-152°
ℓ1
phase-adjusting length of line
λ/4
λ/4
power-splitting hybrid
E_H = 0·40 E_V ∠-152°
relative amplitude adjustment
(a)
twin-element batwing vertically-polarised aerial
1·0∠0°
1·0∠0°
single λ/2 horizontally-polarised dipole
0·89∠-152°
ℓ1
phase-adjusting length of line
50Ω termination
E_H = 0·40 E_V ∠-152°
4 dB attenuator
3dB directional coupler
(b)

Fig. 2 - Alternative arrangements for feeding radiating elements.
(a) adjustable hybrid network *(b)* directional coupler feed

while the relative phases were pre-set by the lengths of distribution feeder, as shown in Fig. 2(*a*). At a later stage difficulties were experienced in waterproofing the transformer and the feeding arrangement was changed to that shown in Fig. 2(*b*).

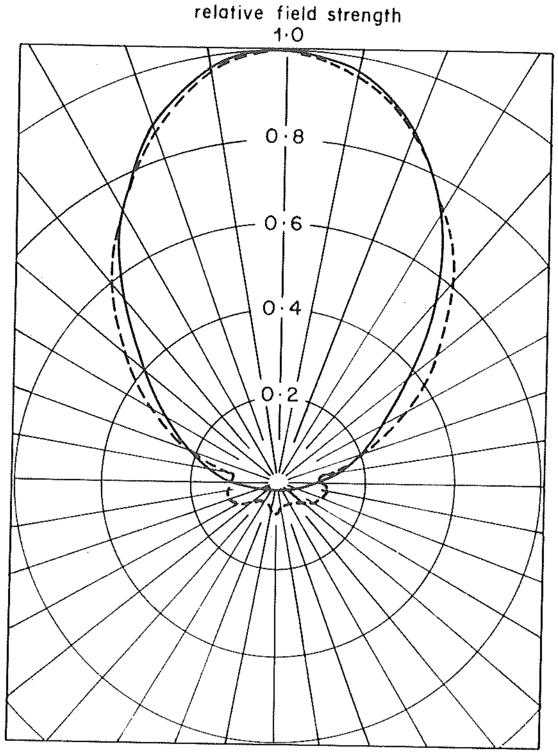

Fig. 3 - Horizontal radiation pattern of vertically and horizontally polarised components.
——— Vertically-polarised component
– – – – Horizontally-polarised component

4. Setting up procedure

The radiation pattern of each aerial was measured in each plane. The patterns in the horizontal plane, shown in Fig. 3, were very similar but the vertical radiation patterns shown in Fig. 4 differ considerably.

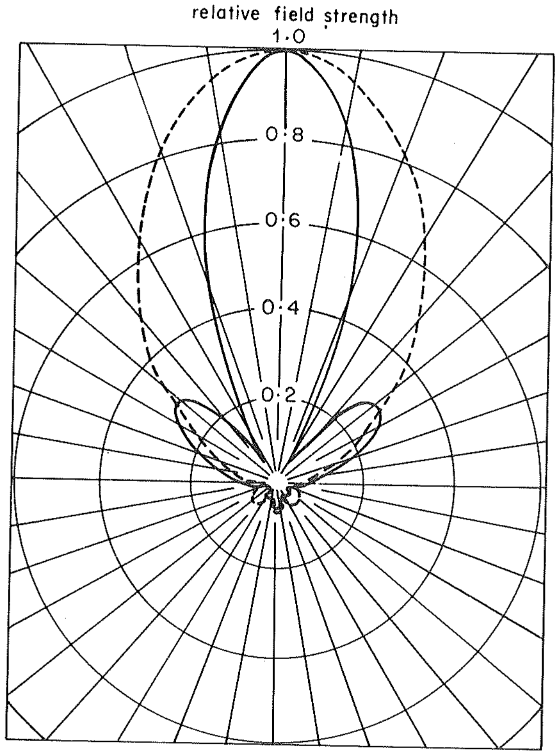

Fig. 4 - Vertical radiation pattern of vertically and horizontally polarised components.
——— Vertically-polarised component
– – – – Horizontally-polarised component

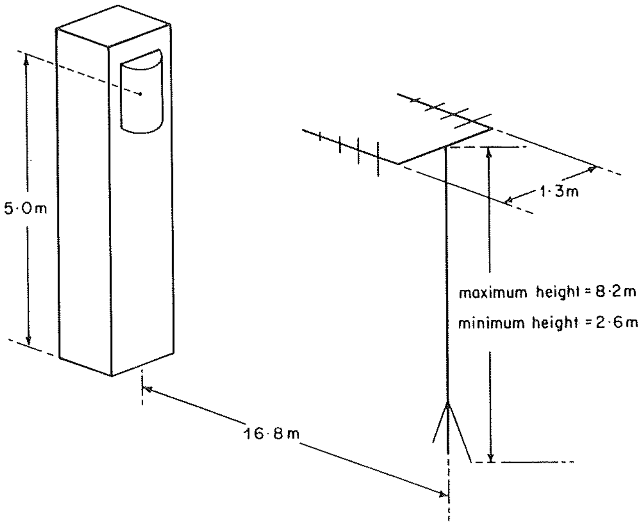

Fig. 5 - Physical disposition of measurement aerials.

A comparison of the areas of the patterns indicated that the aerial gains differed by 4 dB. The feeding network was accordingly set up to give the required ratio under matched conditions and the cables were cut to take account of the phase shift through the network.

It was considered desirable to carry out an independent check on the relative amplitudes and phases of the radiated fields. This was done at base using the arrangement of Fig. 5. in order to eliminate the effect of reflections from the ground. The aerial panel was mounted at a height of 5·0 m a.g.l. and the field in the direction of the maximum of the horizontal radiation patterns was sampled by a pair of log-periodic aerials, one vertical and one horizontal, of which the height above ground level could be adjusted in range 2·6 m to 8·2 m. A recording of the variation with height of the amplitudes of the two components of the field is shown in Fig. 6 and the relative phase in Fig. 7. It may be seen that the ground reflected component of field is pronounced for the horizontally-polarised case but considerably less for the vertically-polarised case.

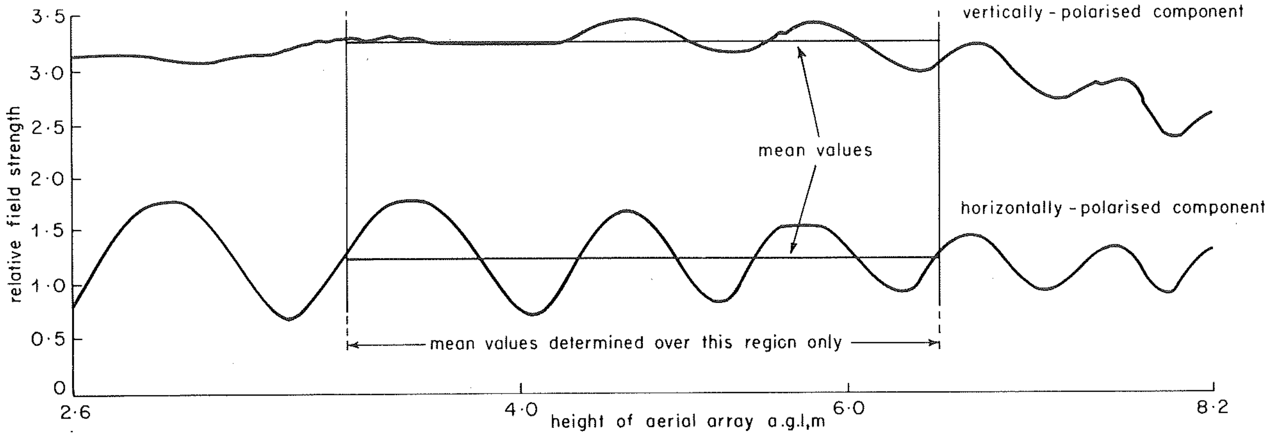

Fig. 6 - Variation with aerial height of component amplitudes.

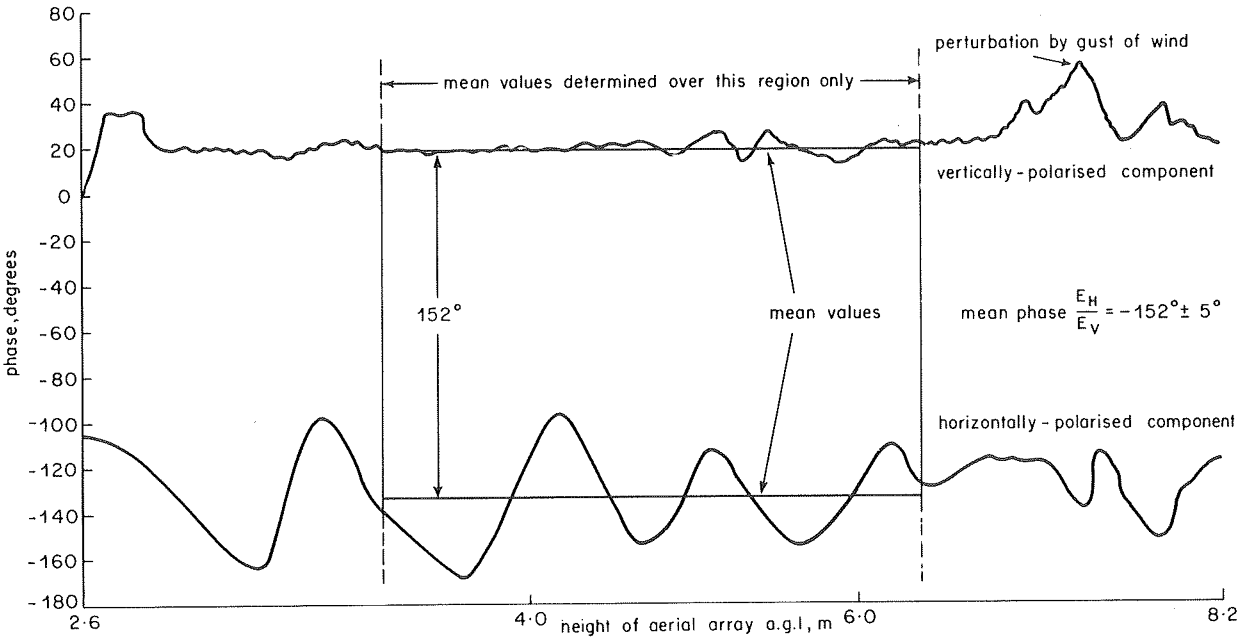

Fig. 7 - Variation with aerial height of relative phase of signal components.

A comparison of the mean values of the two components for aerial heights of about 5 m (to avoid v.r.p. effects, which are apparent at greater heights) shows a ratio of $0{\cdot}385\angle 152^\circ$; this was considered to be sufficiently close to the target of $0{\cdot}40\angle 152^\circ$. In a separate measurement it was shown that the effective gains of the log-periodic aerials did not differ by more than 0·5 dB.

It was thought desirable to be able to monitor the performance of the aerial after installation on the mast at Rosneath, but it would be impracticable to try to measure the polarisation ratio directly. Instead it was decided to check that the reflection from the surface of the water is plane-polarised at an angle of 45°, at least under still water conditions. To do this, a special receiving aerial is required which will reject the direct component of signal arriving at an angle of about 1·5° above the horizontal while accepting the reflected component arriving at an angle of 2·5° below the horizontal. The test receiving aerial comprises two standard measuring yagi aerials mounted with a 2 m separation on a vertical pole. The aerials are positioned in the horizontal plane to give a null at the required angle when connected with equal-length feeders to the combining transformer. The polarisation of the two aerials may be set at 45° in either sense in order either to maximise or minimise the component reflected from the water. The measured pattern of the array, shown in Fig. 8, has a minimum within 0·5° of the desired angle.

5. Conclusions

A panel aerial has been made to give a specified degree of elliptical polarisation. The chief problem encountered was that of verifying that the design performance had been achieved. In the manufacture of an aerial for service use, comprising an array of similar panels, the problem of testing would be less acute since a simple comparison with an aerial of known performance could be arranged. Nevertheless, such an aerial would require more detailed checks than a normal linearly polarised one.

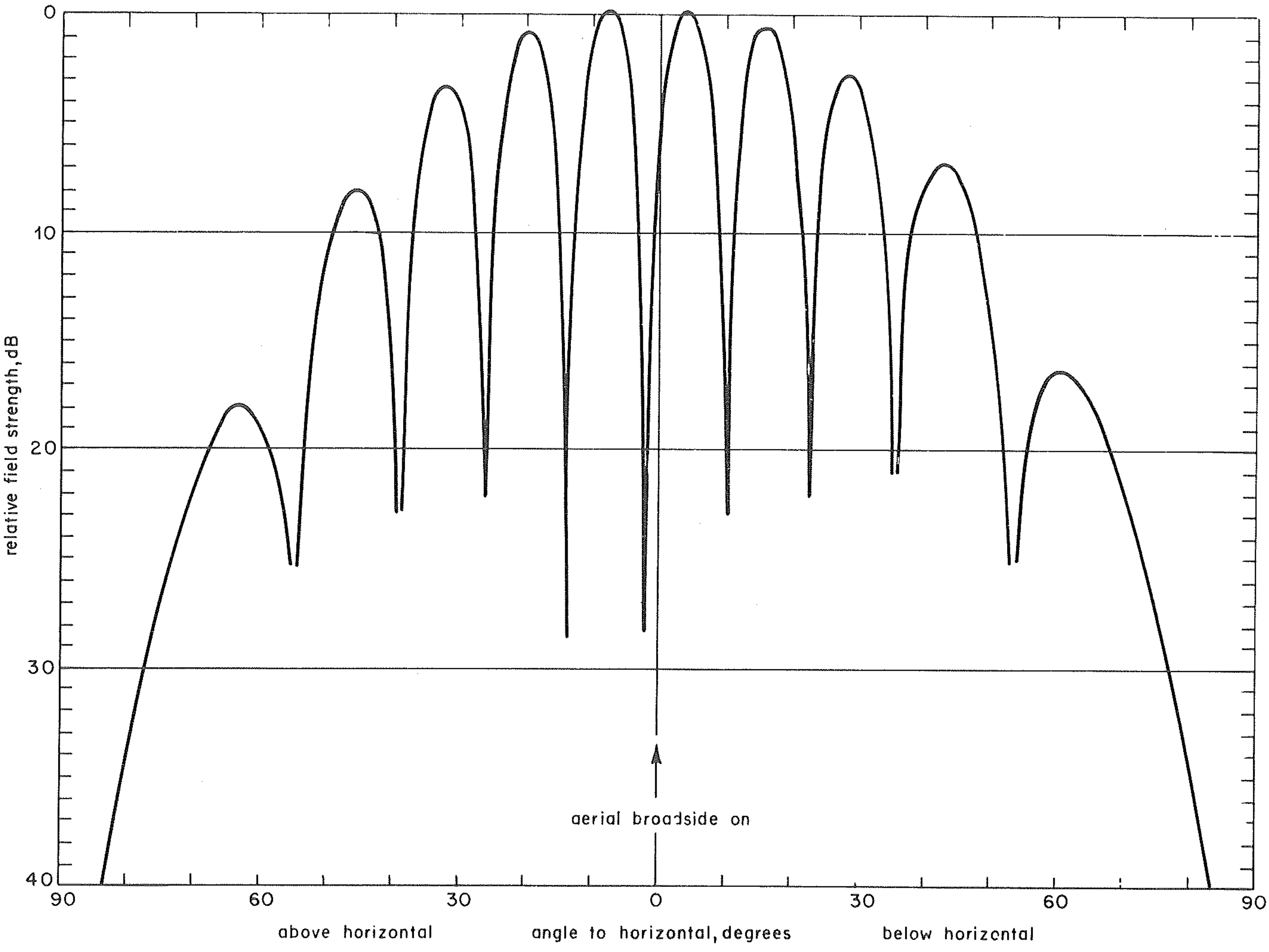

Fig. 8 - Vertical radiation pattern of test receiving aerial.

6. References

1. Television reception over sea paths: the effect of the tide. BBC Research Department Report No. 1970/22.
2. Television reception over sea paths: the effect of polarisation. BBC Research Department Report in preparation.
3. UHF Relay Stations: vertically-polarised printed panel aerial. BBC Research Department Report No. 1970/17.
4. British Patent Specification No. 817,740.

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